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Authors

Jardine, L.J.

Shihab-Eldin, A.

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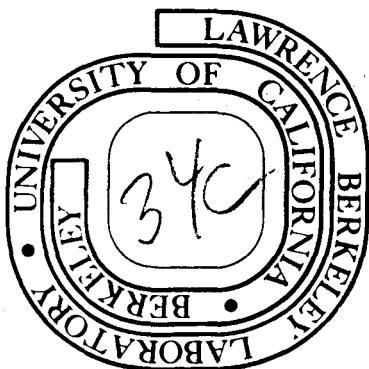
L. J. Jardine and A. Shihab-Eldin

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ALPHA DECAY OF ^{210}At TO LEVELS IN ^{206}Bi [†]

L. J. Jardine and A. Shihab-Eldin

Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

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ABSTRACT: The alpha decay of ^{210}At has been investigated with α - γ coincidence techniques. Spins of ^{206}Bi levels below 500 keV have been deduced from recent electron-capture studies of ^{206}Po , reaction studies of ^{206}Bi and present results. Calculations of the alpha decay rates and electromagnetic transition probabilities using wave functions in a truncated configuration space are successfully compared with the experimental results.

[†]Work done under the auspices of the U. S. Atomic Energy Commission.

RADIOACTIVITY ^{210}At [from $^{209}\text{Bi}(\alpha,3n)$]; measured E_{γ} , I_{γ} , I_{α} , α - γ coinc;
deduced α branching. ^{206}Bi deduced levels, J , π . Ge(Li), semi detectors,
semi-Ge(Li) coinc.

1. Introduction

Recent studies^{1,2)} of the electron-capture decay of ^{206}Po and the $^{205}\text{Tl}(\alpha,3n\gamma)^{206}\text{Bi}$ reaction^{3,4)} have provided details on both the energies and decay characteristics of many ^{206}Bi states. Studies^{5,6)} of the alpha groups from the weak alpha decay of ^{210}At have provided information only on the energies of a few low-lying states of ^{206}Bi because of the lack of α - γ coincidence measurements. This leads to an uncertainty in the placement of several weak low energy transitions observed^{1,2)} in the electron-capture decay of ^{206}Po for which the multipolarities have been determined. If some of these transitions could be identified with the decay of states populated by the α decay of ^{210}At , the spins of ^{206}Bi states could be better defined in order to test theoretical calculations of α -decay rates and γ -ray branching ratios of electromagnetic transitions.

We have performed a reinvestigation of the weak α -decay branch of ^{210}At where the main emphasis was to supplement previous high resolution magnetic spectrometer measurements⁵⁾ of the α spectra with α - γ coincidence measurements. Four γ rays depopulating states of ^{206}Bi have been observed, two of which have not been previously reported. Experimental α -decay rates are compared with theoretical calculations²⁰⁾ that used assumed shell model configurations. Electromagnetic transition probabilities for the γ -ray decay of the low-lying states have also been calculated and are compared to the experimental results.

2. Experimental

2.1. SOURCE PREPARATION

Astatine was produced via the $^{209}\text{Bi}(\alpha,3n)^{210}\text{At}$ reaction by bombarding bismuth metal targets with 39-MeV α particles in the 88-inch cyclotron at the Lawrence Berkeley Laboratory. Small amounts of ^{209}At from the $(\alpha,4n)$ reaction were observed; the only other alpha emitting impurities were ^{211}At and its short-lived daughter ^{211}Po . Chemical purification and separation of ^{210}At from the target was achieved by heating the target to 300°C and directly collecting the evolved astatine on a collimated aluminum counting disk attached to a cold finger. A thin layer ($\approx 3 - 10 \mu\text{g}/\text{cm}^2$) of aluminum was vacuum-sublimed over the sources to prevent migration of the volatile astatine and attenuate growth of the long-lived α activity ^{210}Po on the detector and surrounding surfaces.

2.2. ALPHA AND GAMMA-RAY SPECTRA

The α spectrum of ^{210}At was measured (fig. 1b) with a 6-mm diameter Au-Si surface barrier detector (system resolution 16 keV (FWHM) at 4.8 MeV). We show in Table 1 the energies and intensities of α groups of ^{210}At reported by ref. ⁵) along with our results. Because of the superior resolution of ref. ⁵), no attempt was made to extract the intensities of unresolved α groups after our sum intensities were found to agree. The main decay mode of ^{210}At is 99.985% electron-capture so that the γ -ray singles spectrum is dominated by transitions from this decay mode. Shown in fig. 1a is a γ -ray spectrum of a ^{210}At source taken with a Ge(Li) detector. All observable transitions are due to the electron-capture branch and the need to do α - γ coincidence measurements to observe weak γ transitions with the α -decay mode is readily apparent.

2.3. ALPHA-GAMMA COINCIDENCE MEASUREMENTS

Three parameter (E_α , E_γ , Δt) coincidence measurements were made with conventional high-rate pulse electronics coupled to a 4096-channel analogue-to-digital converter of the successive approximation type⁷⁾ and a PDP-7 computer system^{8,9)}. A fast coincidence electronic arrangement previously described¹⁰⁾, with leading edge timing¹¹⁾ was used. The detectors employed were a 10 cm³ (active volume) Ge(Li) detector (system resolution 1.5 keV (FWHM) at 122 keV) and a 6-mm diameter Au-Si surface barrier detector (system resolution 16 keV (FWHM) at 4.8 MeV). The axis of the two detectors were positioned at 180° with respect to each other. The source was ≈ 3 mm from the α -detector and ≈ 7 mm from the γ -ray detector. Energy calibration of the detectors was made by using known¹²⁾ γ -ray energies from the electron-capture decay of ^{210}At and the α -particle energies of ^{210}Po , ^{211}At and ^{211}Po . The relative efficiency of the Ge(Li) detector was determined under the same conditions using the methods of ref. ¹³⁾. The width of the prompt time distribution of the system (as determined from the 5.3-MeV α particle and 75-keV γ ray of ^{243}Am) was about 20 nsec. The three parameter data were stored serially on magnetic tape and later sorted out on the LBL-CDC 7600 computer system using a resolving time of ≈ 40 nsec.

When gating on the three alpha groups α_{83} , α_{140} and α_{167} , the γ -ray spectra shown in fig. 2 were obtained. These spectra are corrected for chance coincidences and for contributions from the tailing of higher-energy α groups contained within the gates. None of these α groups were found to populate states with measurable α - γ time delays ($\gtrsim 20$ nsec).

Analysis of the spectra of fig. 2 yielded the γ -ray energies and relative intensities shown in Table 2. In order to check the consistency of these

results with the level scheme (Section 3), the relative intensities of the α_{83} , α_{140} and α_{167} groups were calculated using the relative γ -ray intensities of Table 2 and theoretical internal conversion coefficients assuming that the four γ rays were of pure M1 multipolarity. These results are shown in Table 3 and are compared with the α -singles measurements of ref. ⁵). It can be noted that if one assumes a pure E2 multipolarity for any of the four transitions, the agreement becomes poor; this is a very weak argument supporting tentative assignments of M1 multipolarity for these four transitions.

3. Decay Scheme

The level scheme of ^{206}Bi deduced from our α - γ coincidence data is shown in fig. 3. Relative alpha intensities of ref. ⁵) and calculated ¹⁴) hindrance factors are shown on the right. We have also included known levels below 500 keV observed from the electron-capture decay ^{1,2}) of ^{206}Po and the $^{205}\text{Tl}(\alpha, 3n\gamma)$ reaction ^{3,4}) from which spin and parity assignments for all levels, except those at 83 and 167 keV, were derived.

The ground-state of ^{206}Bi has a measured spin ¹⁵) of 6 and can be interpreted as of even parity because of its electron-capture decay characteristics to ^{206}Pb and its probable shell model configuration.

The first 4^+ excited state at 60 keV has a measured ¹⁶) half-life of 7.8 ± 0.3 μsec and is depopulated ^{1,17}) by a highly converted E2 transition; thus our α - γ coincidence measurements could give no additional information.

The state at 83 keV receives the most intense α -particle population of the excited states; an 83 ± 1 -keV γ ray was found to be in coincidence with the α_{83} group (fig. 1a). An 82.8 ± 0.1 -keV M1 transition has been observed ¹) in the electron-capture decay of ^{206}Po and has been assigned to depopulate this state.

A spin and parity for this state of 5^+ is consistent with the α -decay rates (subsection 4.1) and the γ -ray multipolarity.

A 7^+ state at 140 keV which decays to the ground state by a 139.5 ± 1.0 keV M1 transition has been observed in the $^{205}\text{Tl}(\alpha, 3n\gamma)^{206}\text{Bi}$ reaction^{3,4}). A 140 ± 1 -keV γ ray was observed in coincidence with the α_{140} group (fig. 1b), and this transition is believed to be the same one observed in the reaction study.

A state of 167 keV is established by the α_{167} group. γ rays of 106 ± 1 and 167 ± 2 keV were found to be in coincidence with this α group (fig. 1c). Neither of these two γ rays have been definitely observed in the electron-capture studies of ^{206}Po . The decay of this state to the 6^+ ground state and the first excited 4^+ state at 60 keV, the requirement of M1 multipolarity for these two γ rays (subsection 2.3) and the theoretical α -decay rate calculations (subsection 4.1) make a spin and parity assignment of 5^+ tentative, but most probable.

The weak α group which defines⁵) a state at 401 ± 4 keV was not intense enough to be observed in our measurements. This energy does not agree within error limits with the 2^+ state (assigned^{1,2}) the dominant configuration $(\pi(h_{9/2})^{\nu}(f_{5/2})^{-1}(p_{1/2})^{-2})_{2_1^+}$ at 409.2 ± 0.2 keV populated in the electron-capture decay of ^{206}Po . Further, the α -rate calculations of Section 4.1 are not consistent with such an intensity for α decay to such a 2^+ configuration. Thus, it is believed possible for these to be two different states with the 401 keV state perhaps belonging to one of the $(\pi(h_{9/2})^{\nu}(p_{3/2})^{-1}(p_{1/2})^{-2})_{3,4,5,6^+}$ configurations.

In the electron-capture decay of ^{206}Po a 3^+ state (depopulated by an internally converted 10.84 keV M1 transition) at 70.8 keV and a 4^+ state (depopulated by three M1 transitions) at 200.4 keV were observed^{1,2}). However, the α -singles measurements of ref.⁵) showed that there was no appreciable α

population of either of these states and we can set a limit from the data given in fig. 2 of ref. 5) of $\lesssim 5$ relative to 100 for the ground-state α group for the relative intensity of an α group, populating either of these states.

4. Interpretation of Results

The nucleus ^{206}Bi with 123 neutrons and 83 protons is three neutron-holes and one proton removed from the magic ^{208}Pb core. Yet no theoretical wave functions known to us have been generated for this nucleus. Energy level systematics of odd-A nuclei in the lead region suggest that the odd proton and odd neutron occupy the $1h_{9/2}$ and the $2f_{5/2}$ orbitals, respectively. (The latter of which may be justified by considering the experimental¹⁸⁾ level spectrum of the three neutron-hole ^{205}Pb nucleus which is shown in fig. 4.) As the $1h_{9/2}$ proton orbital is separated (fig. 4) from the next proton orbital ($2f_{7/2}$) in ^{209}Bi by ≈ 800 keV, it might be possible to describe the lowest-lying states of ^{206}Bi by pure configurations arising from the $1h_{9/2}$ proton coupled with the $2f_{5/2}$ neutron hole. This would give six even parity states of spins 2, 3, 4, 5, 6 and 7. Excited (neutron-hole) states (fig. 4) of ^{205}Pb occur at $2.3(\nu(3p_{1/2})^{-1})$ and $267(\nu(3p_{3/2})^{-1})$ keV. Thus the lower-lying states of spin 4 and 5, might a priori be expected to be rather admixed (with configurations of $\pi(h_{9/2})\nu(f_{5/2})^{-1}(p_{1/2})^{-2}$ and $\pi(h_{9/2})\nu(p_{1/2})^{-1}(f_{5/2})^{-2}$) because of strong configuration interactions while states of spin 2, 3, 6 and 7 might be expected to be somewhat more "pure" in character. With the $3p_{3/2}$ neutron-hole state of ^{205}Pb separated by 267 keV from the $2f_{5/2}$ hole state, even parity states of spin 3, 4, 5 and 6 are also expected to be admixed although to a lesser degree. With the next excited state of ^{205}Pb occurring at 580 keV, perhaps the lowest-lying states ($\lesssim 400$ keV) of ^{206}Bi may approximately be described in terms of the three configurations $(\pi(h_{9/2})\nu(f_{5/2})^{-1}(p_{1/2})^{-2})_{J=2,3,4,5,6,7}^{+}$,

$(\pi(h_{9/2})^v(p_{1/2})^{-1}(f_{5/2})^{-2})_{J=4_2, 5_2^+}$ and $(\pi(h_{9/2})^v(p_{3/2})^{-1}(p_{1/2})^{-2})_{J=3_2, 4_3, 5_3, 6_2^+}$ which are summarized in fig. 4. Within this limited configuration space we have generated (by trial and error) a set of wave functions for the 6_1^+ , 4_1^+ , 7_1^+ , and 5_2^+ states that correctly reproduce the experimental results from the α decay studies so far as they are presently known when the α -decay rates and electromagnetic transition rates are calculated.

4.1. THEORETICAL ALPHA DECAY RATES

Extension of the α -decay rate theory of ref. ¹⁹⁾ to spherical odd-odd nuclei has been recently carried out by Shihab-Eldin, Jardine and Rasmussen ²⁰⁾.

Below we summarize the results of the calculation of the α -decay rates for $^{210}_{85}\text{At}^{125}$ which has been assumed to have the pure shell model ground-state configuration $(\pi(h_{9/2})^3_{9/2}v(p_{1/2})^{-1})_{5^+}$.

In Table 4 we show the relative theoretical alpha decay rates (labeled as set I) to ^{206}Bi states assuming the pure shell model configurations discussed in Section 4 and compare them with the experimental ⁵⁾ relative intensities of α groups. The excellent agreement between theory and experiment for the relative alpha intensity to the 6_1^+ and 7_1^+ states (at 0 and 140 keV, respectively) may indicate that pure configurations can be ascribed to these states. The calculations also agree with the experimental limits set for the possible α groups to the 3_1^+ , 4_2^+ and 2_1^+ states (at 70.8, 200.4 and 409.2 keV, respectively). It was found ²⁰⁾ that the disagreement in the relative intensities for the 4_1^+ , 5_1^+ and 5_2^+ states (at 59.9, 82.8 and 167 keV, respectively) with respect to the 6_1^+ ground-state could be removed by the inclusion of admixtures of the $(\pi(h_{9/2})^v(p_{3/2})^{-1}v(p_{1/2})^{-2})$ and the $(\pi(h_{9/2})^v(p_{1/2})^{-1}(f_{5/2})^{-2})$ configurations with the $(\pi(h_{9/2})^v(f_{5/2})^{-1}(p_{1/2})^{-2})$ configuration. We summarize by giving in

Table 4 a second set (labeled as set II) of calculated α -decay rates, in particular for the 4_1^+ , 5_1^+ and 5_2^+ states, using admixed wave functions for ^{206}Bi containing these configurations. Details leading to this conclusion are given in ref. ²⁰). The use of admixed wave functions (discussed in more detail in subsection 4.2) in the calculation of electromagnetic transition probabilities and α -decay rates gives better overall agreement with the experimental results.

4.2 ELECTROMAGNETIC TRANSITION RATES

Following the formulation developed by Struble²¹), we have computed electromagnetic transition probabilities for the γ -ray decay of most ^{206}Bi states populated by the α decay of ^{210}At using a set of trial wave functions. It can be noted that for pure shell model configurations M1 γ -ray decays of the 5_2^+ state at 167 keV to the 6_1^+ and 4_1^+ states at 0 and 60 keV, respectively, are ℓ -forbidden $\left[(\pi(h_{9/2})v(p_{1/2})^{-1}(f_{5/2})^{-2})_{5_2^+} \longrightarrow (\pi(h_{9/2})v(f_{5/2})^{-1}(p_{1/2})^{-2})_{6_1^+, 4_1^+} \right]$. Hence admixtures in the wave functions will be required in order to reproduce the experimental results. A set of such admixed wave functions (shown in Table 5), with choices for the admixtures guided in part by the α -decay rate calculations of subsection 4.1, was found by trial and error which were consistent in predicting the correct experimental electromagnetic transition properties observed for the 4_1^+ and 5_2^+ states in the following way.

The measured¹⁶) half-life of 7.8 ± 0.3 μsec for the 60 keV E2 $4_1^+ \rightarrow 6_1^+$ transition provides a convenient starting point. Using effective charges²²) of 1.5e and 0.87e for the proton and neutron, respectively, a pure configuration for the 6_1^+ ground state and recalling from subsection 4.1 that a $\pi(h_{9/2})v(p_{3/2})^{-1}(p_{1/2})^{-2}$ admixture was required for the 4_1^+ state, calculation of the E2 transition probability with the wave functions for the 4_1^+ and 6_1^+ states shown in Table 5 gives the result of $1.2 \times 10^3 \text{ sec}^{-1}$ compared to the

experimental¹⁶⁾ value of $(1.2 \pm 1) \times 10^3 \text{ sec}^{-1}$. (It was found that the electromagnetic E2 transition probability between the pure configurations $(\pi(h_{9/2})\nu(f_{5/2})^{-1}(p_{1/2})^{-2})_{4_1^+} \rightarrow (\pi(h_{9/2})\nu(f_{5/2})^{-1}(p_{1/2})^{-2})_{6_1^+}$ was $\approx 20\%$ too high. A two component wave function for the 4_1^+ state of the form $\sqrt{0.80} | \pi(h_{9/2})\nu(f_{5/2})^{-1}(p_{1/2})^{-2} \rangle + \sqrt{0.20} | \pi(h_{9/2})\nu(p_{1/2})^{-1}(f_{5/2})^{-2} \rangle$ also gave the correct transition probability. However, such a wave function was neither consistent with the α -decay rate calculations of subsection 4.1 nor with the M1 γ -ray branching ratio of $(5_2^+ \rightarrow 4_1^+) / (5_2^+ \rightarrow 6_1^+)$ which is discussed next.)

Electromagnetic transition rates for the M1 γ -ray decay of the 5_2^+ state at 167 keV were found to be rather sensitive to small admixtures of the three configurations whereas the alpha decay rates²⁰⁾ for the 5_2^+ state were somewhat insensitive. Using effective²³⁾ gyromagnetic ratios, a pure wave function for the 6_1^+ state, the three component (Table 5) wave function for 4_1^+ state and the trial wave function for the 5_2^+ shown in Table 5, the M1 γ -ray branching ratio $(5_2^+ \rightarrow 4_1^+) / (5_2^+ \rightarrow 6_1^+)$ was found to be 2.6. This ratio can be compared with the experimental ratio of 2.7 ± 0.5 . It should be emphasized that agreement between the theoretical and experimental branching ratio could not be found for any choice of amplitudes limited only to the two lower configurations and inclusion of the third configuration $\pi(h_{9/2})\nu(p_{3/2})^{-1}(p_{1/2})^{-2}$ was required in this limited configuration space. (This is mainly due to a larger diagonal matrix element for the $3p_{3/2}$ single-particle transition than for a $3p_{1/2}$.) The lack of a second transition from either the 5_1^+ state or the 7_1^+ presently precludes any further comment about their wave functions.

We summarize by showing in Table 5 a set of deduced wave functions for the 6_1^+ , 4_1^+ , 7_1^+ and 5_2^+ states which give agreement with the known experimental results. Finally, we show in Table 6 the absolute electromagnetic transition

rates involving these four states calculated from the wave functions of Table 5.

5. Conclusions

Both α - and γ -decay rate calculations indicated that an appreciable $\pi(h_{9/2})\nu(p_{3/2})^{-1}(p_{1/2})^{-2}$ admixture in the 4_1^+ and 5_1^+ states was required in order to get agreement between theory and experiment. When theoretical wave functions in a larger and more realistic configuration space become available, it will be interesting to note if this qualitative observation is still valid. Also additional γ -ray branching ratios can be tested with such wave functions as much more data are now available for the higher-lying ^{206}Bi states obtained from recent detailed studies^{1,2)} of the electron-capture decay of ^{206}Po .

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Table 1. α -particle groups emitted by ^{210}At .

α -particle energy ^a (MeV)	^{206}Bi state energy (keV)	Relative abundance		Hindrance Factor
		ref. 5)	this work	
5.5240±0.0015	0	100	100	36
5.4650±0.0015	60±2	26±2	} 117±10	70
5.4420±0.0015	83±2	95±6		
5.386±0.001	140±2	14±2	} 99±10	49
5.361±0.001	166±2	83±6		
5.131±0.002	401±4	1.2±0.4	—	21

^a These values were measured by ref. 5).

Table 2. γ -rays measured in coincidence with ^{210}At alpha particles.

γ -ray energy (keV)	Relative γ -ray intensity	α gate
83 \pm 1	766 \pm 153	α_{83}
140 \pm 1	174 \pm 35	α_{140}
106 \pm 1	272 \pm 54	α_{167}
167 \pm 2	100	α_{167}

Table 3. Comparison of relative α transition intensities determined from singles and α - γ coincidence measurements as described in text.

Excited state energy (keV)	Relative abundance	
	singles ^a	α - γ coincidence
83	95±6	93±26
140	14±2	14
167	83±6	92±26

^aThese values were measured by ref. 5).

Table 4. A comparison of the experimental⁵⁾ and theoretical relative alpha intensities in the decay of $^{210}_{85}\text{At}$

^{206}Bi configurations ^a		Relative α intensity			
J^π	E (keV)	expt ^b	calculated (I) ^{c,d}	calculated (II) ^{c,e}	
$(\pi(h_{9/2})^v(f_{5/2})^{-1}(p_{1/2})^{-2})_{J^\pi}$	6_1^+	0	100	100	
	4_1^+	60	26±2	14	26
	3_1^+	70	≤ 5 ^f	0.3	
	5_1^+	83	95±6	11	83
	7_1^+	140	14±2	15	
	2_1^+	409	≤ 5 ^f	0.005	
$(\pi(h_{9/2})^v(p_{1/2})^{-1}(f_{5/2})^{-2})_{J^\pi}$	5_2^+	167	83±6	95	76
	4_2^+	200	≤ 5 ^f	0.13	

^a Spin and energy assignments were taken from refs. ¹⁾ and ²⁾.

^b Experimental relative intensities were taken from ref. ⁵⁾.

^c The value of the parameter R_0 used was 8 fm.

^d Pure shell model configurations were assumed for both ^{206}Bi and ^{210}At .

^e Configuration admixed wave functions for ^{206}Bi as discussed in ref. ²⁰⁾ were used. (These results are from Table 3 (Set II) of ref. ²⁰⁾.)

^f Alpha groups not observed by ref. ⁵⁾ can be given an upper limit of ≤ 5 relative to 100 for the ground state alpha group.

Table 5. Wave functions for some ^{206}Bi states deduced from the electromagnetic transition probabilities calculations of section 4.2. These give consistent results with experiment when electromagnetic transition probabilities and α -decay rates are calculated.

Energy (keV)	J^π	configurations ^a		
		$ \pi(h_{9/2})\nu(f_{5/2})^{-1}(p_{1/2})^{-2}\rangle$	$ \pi(h_{9/2})\nu(p_{1/2})^{-1}(f_{5/2})^{-2}\rangle$	$ \pi(h_{9/2})\nu(p_{3/2})^{-1}(p_{1/2})^{-2}\rangle$
0	6_1^+	1.0		
60	4_1^+	$\sqrt{0.74}$	$-\sqrt{0.10}$	$-\sqrt{0.16}$
140	7_1^+	1.0		
167	5_2^+	$\sqrt{0.05}$	$\sqrt{0.67}$	$-\sqrt{0.28}$

a) Numbers in the table represent the amplitudes of the configurations composing the state.

Table 6. Comparison of electromagnetic transition probabilities, using the wave functions of table 5, in the decay of ^{206}Bi states with available experimental data.

Transition ($J_i \rightarrow J_f$)	E (keV)	Relative γ -ray branching intensity (expt.)	Multipolarity (expt.)	Theoretical Transition Probability ^a $T(\lambda) \times 10^{-9} \text{ sec}^{-1}$		
				(calc.)		(expt.)
				M1	E2	
$5_2^+ \rightarrow 7_1^+$	27	n.o. ^b	(E2)	0	3.4×10^{-7}	
$5_2^+ \rightarrow 4_1^+$	107	2.7 ± 0.5	(M1)	3.00	2.5×10^{-4}	
$5_2^+ \rightarrow 6_1^+$	167	1.0	(M1)	1.16	5.8×10^{-3}	
$7_1^+ \rightarrow 6_1^+$	140	1.0	M1	6.63	0.013	
$4_1^+ \rightarrow 6_1^+$	60	1.0	E2	0	1.18×10^{-6}	$(1.2 \pm 0.1) \times 10^{-6}$

a) The value for the oscillator parameter ν used in the calculation of $T(E2)$ was 0.1659. Other parameters are discussed in text.

b) Transition was not observed.

FIGURE CAPTIONS

Fig. 1. Gamma-ray and alpha spectra (with a ^{210}At source) taken with a

(a) Ge(Li) γ -ray spectrometer in the energy range $\approx 40 - 260$ keV

(b) Si(Au) α spectrometer in the energy range $4.7 - 7.5$ MeV.

Fig. 2. Gamma-ray spectra in coincidence with

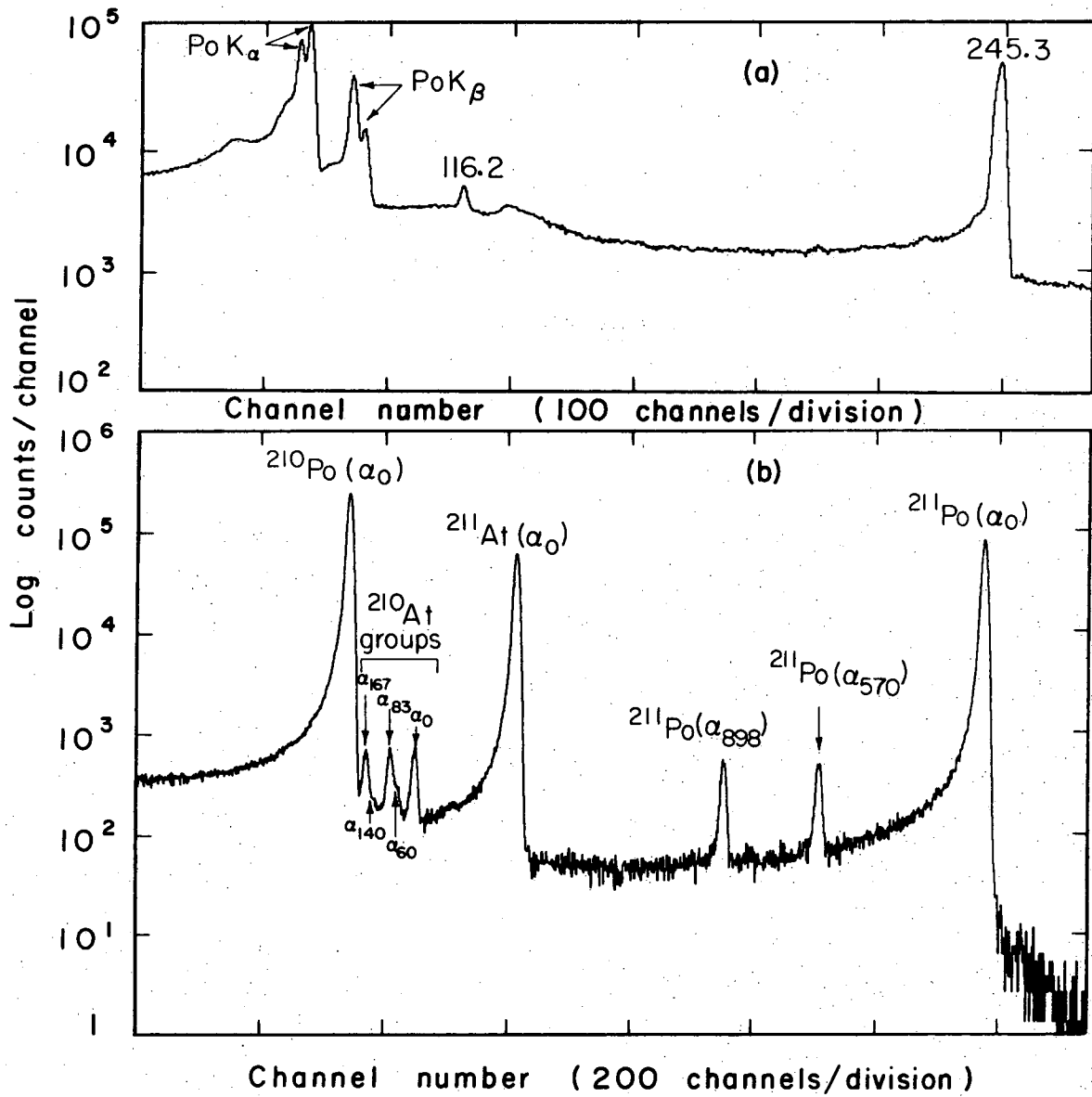
(a) the 5.442 MeV alpha group of ^{210}At (labeled α_{83} gate)

(b) the 5.386 MeV alpha group of ^{210}At (labeled α_{140} gate)

(c) the 5.361 MeV alpha group of ^{210}At (labeled α_{167} gate).

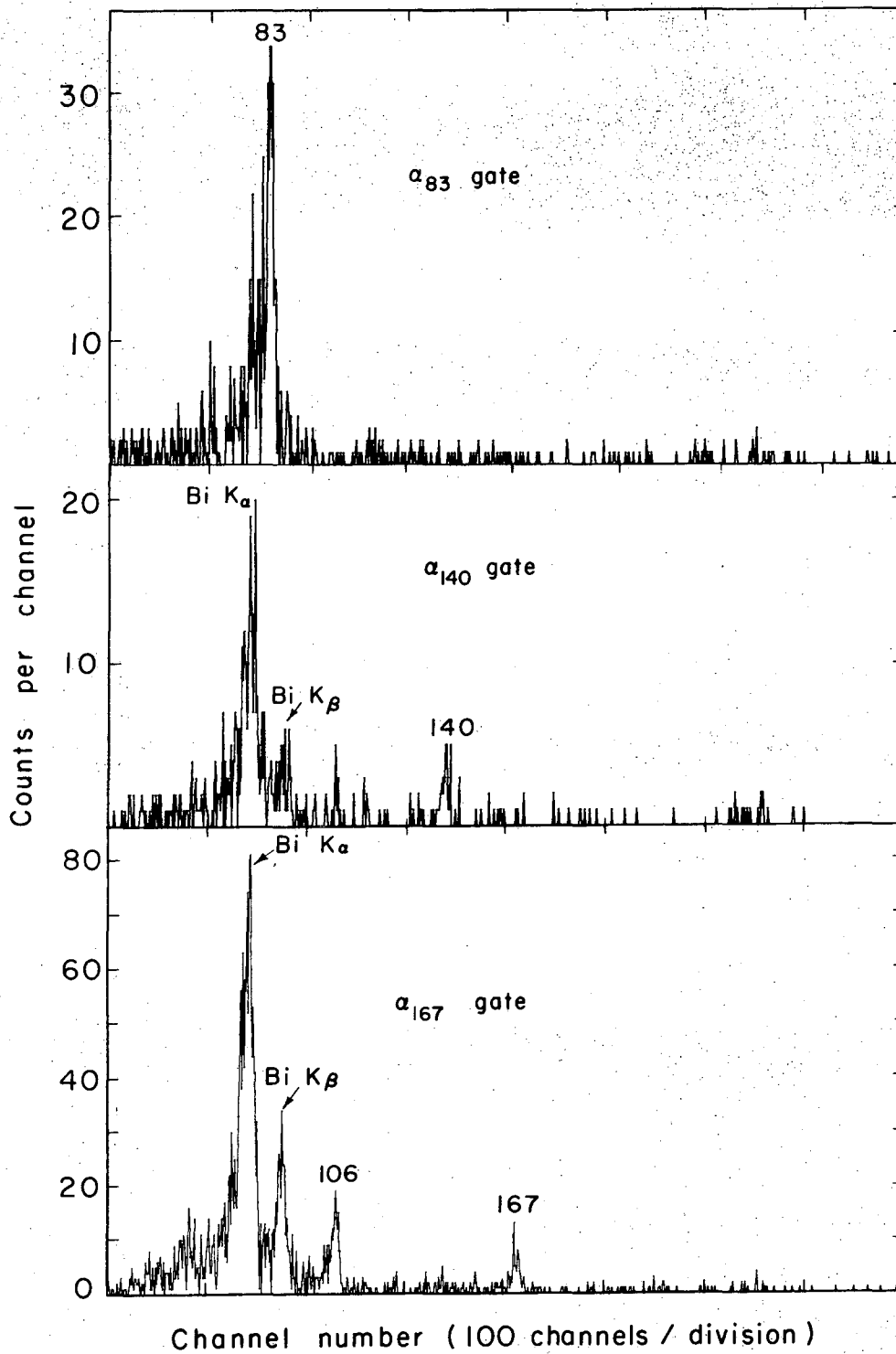
Fig. 3. Level scheme of ^{206}Bi . Relative alpha intensities⁵, relative photon intensities for the 167 keV level and calculated¹⁴ alpha hindrance factors are also shown. Spins, parities and level energies below 0.524 MeV are shown as deduced from previous studies^{1,2,3,4} of the level structure.

Fig. 4. Partial summary of experimental data on levels in ^{206}Bi , ^{205}Pb and ^{209}Bi . Also shown is a representation of the one particle (proton) three (neutron) hole states for ^{206}Bi discussed in the text. These are generated by coupling the three neutron-hole states of spin and parity $5/2^-$, $1/2^-$ and $3/2^-$ with the $9/2^-$ particle state.



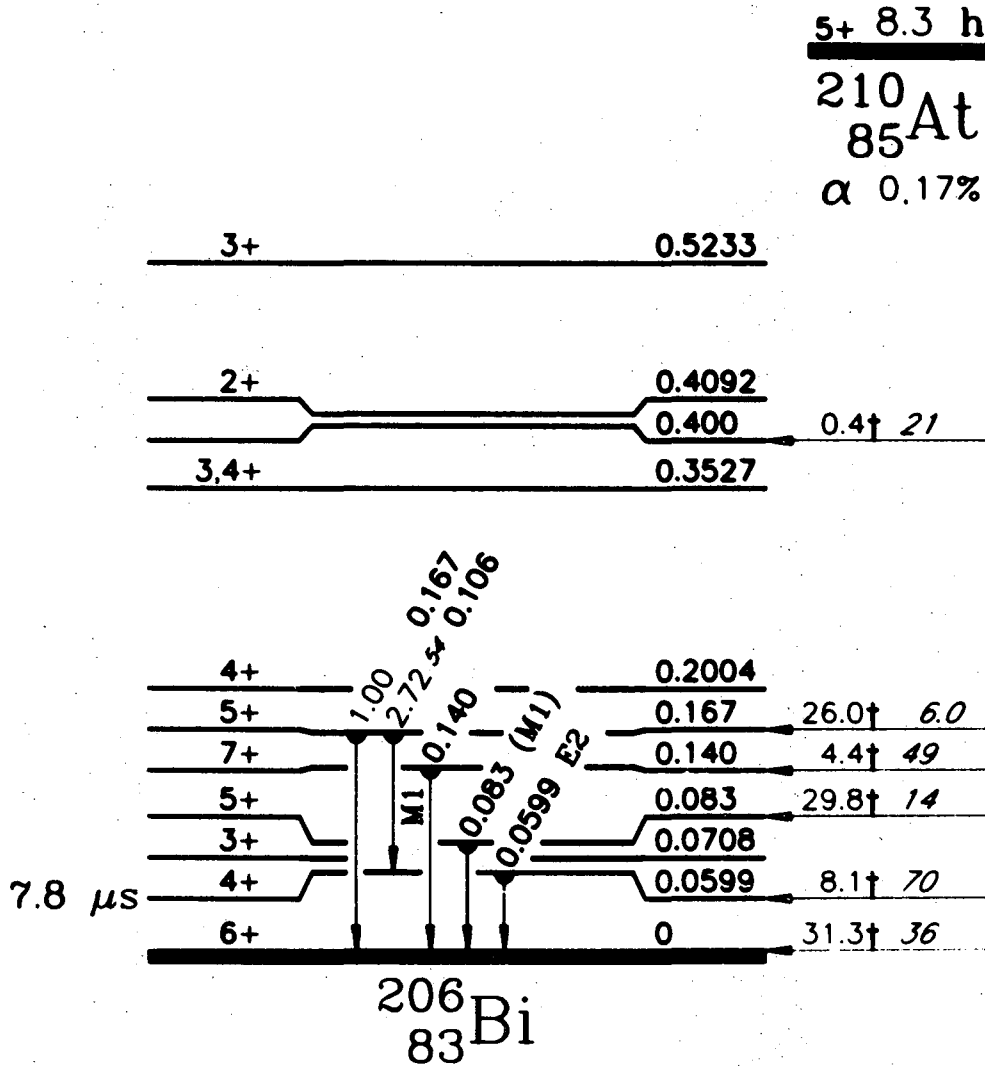
XBL745-3128

Fig. 1



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Fig. 2



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Fig. 3

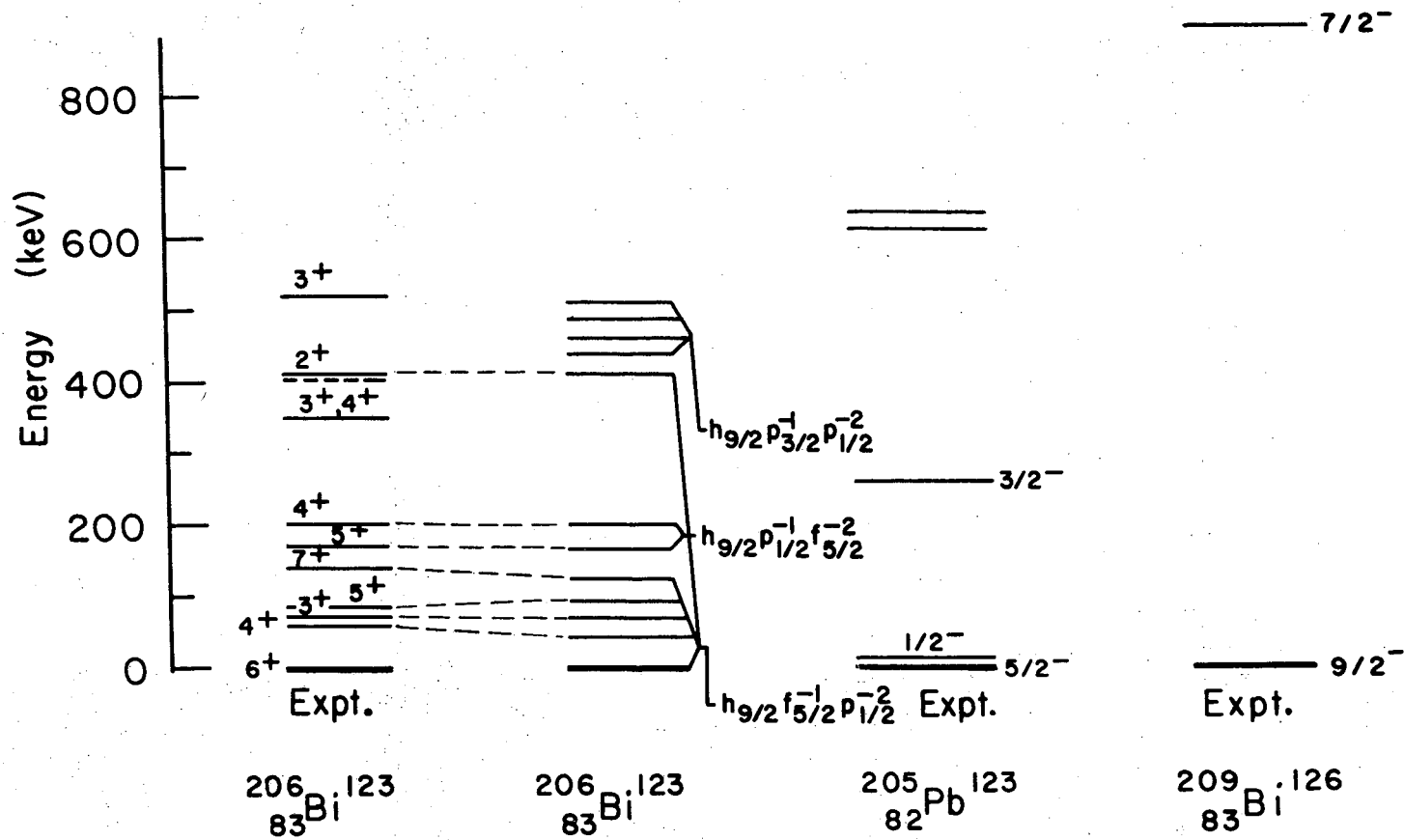


Fig. 4

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TECHNICAL INFORMATION DIVISION
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720